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(56) Documents cited
GB 2078787 A EP 0365249 A2 EP 0144838 A2
US 4892633 A US 4871433 A US 4865708 A
US 4734183 A US 4498969 A US 4448563 A
US 4265729 A

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(54) Magnetron sputtering of magnetic materials in which magnets are unbalanced

(57) A magnetron for sputtering of magnetic materials has a ferromagnetic core with an unbalanced arrangement of magnets providing a plasma entrapping field over the target. In an unbalanced magnetron the magnets of one polarity are not balanced by magnets of the opposite polarity of an equal total strength. The unbalanced arrangement enables the ferromagnetic target to be used without any artificial non-uniformity being introduced into the target to provide the field lines above it. In an unbalanced magnetron some lines of force tend to travel outside the target disc above its surface, in contradistinction to a balanced magnetron where the lines of force tend to travel within the target disc when it is of magnetic material, and thus are useful to effect the plasma (Fig. 4).

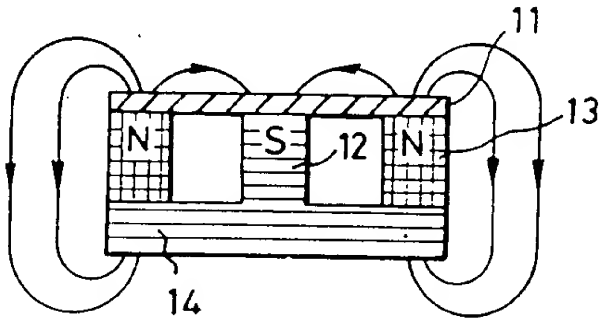

FIG.4.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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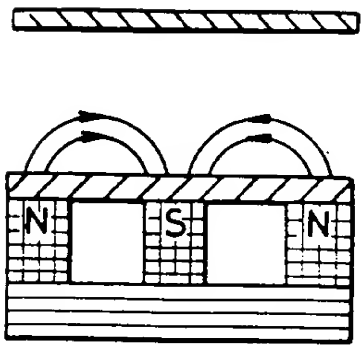

FIG.1.

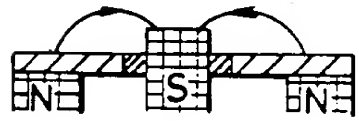

FIG.2.

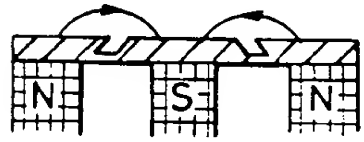

FIG.3.

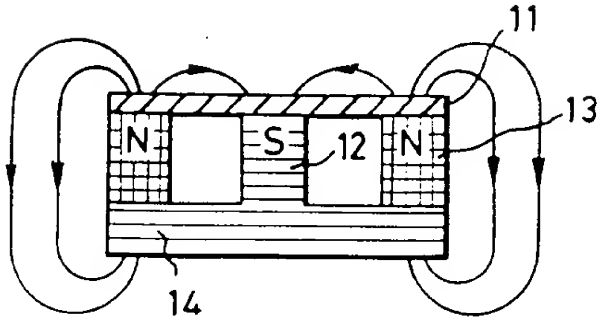

FIG.4.

MAGNETRON SPUTTERING OF MAGNETIC MATERIALS

To deposit films of a target material on to a substrate by sputtering, the target and substrate may be mounted opposite each other in a vacuum system. The target is biased negatively with respect to the anode and a gas (generally inert, such as argon) is introduced. Under the action of the electric field, the gas is ionised, positive ions, bombard the target which is sputtered on to the substrate as a film. To sustain the discharge, the gas pressure is about 10 pascals. With this diode system, deposition rates are relatively low.

To enhance the rate, the ionising electrons may be confined to near the surface of the target by a magentic field. This gives rise to an intense plasma above the target, which provides efficient sputtering at pressures of 1 to 0.1 pascals. A convenient arrangement of a magnetron sputtering system is shown in Figure 1. The target is a disc, with magnets beneath the circumference of the disc, a magnet or a ring of magnets at the centre of the disc all of one polarity and an outer ring of magnets with the opposite polarity. The magnetron is balanced when the total strength of the magnets of one polarity is equal to the total strength of the magnets of the other polarity. A magnetic field is then established above the target. However, if the target is a ferromagnetic material, the magnetic field tends to be confined within the target material and the sputtering rate is reduced to that of a diode.

Various methods have been proposed to improve the sputtering rate for magnetic materials. Instead of a disc, the target is machined as an annulus allowing the centre magnet to protrude above the target (Figure 2). A non-magnetic spacer is placed between the magnet and the annular

have found that with an unbalanced magnetron some lines of force tend to travel outside the disc above its surface and so are useful to affect the plasma. The effect is achieved without the complication of grooving or drilling the target disc.

Examples of the prior art have been described with reference to Figures 1 to 3 and an example of the invention will now be described with reference to Figures 4 to 7. In these Figures,

Figure 1 is a diametral section through a balanced magnetron of the prior art,

Figures 2 and 3 are details of two different modifications of the prior art magnetron of Figure 1,

Figure 4 is a similar section through a magnetron according to the present invention, and

Figures 5 to 7 show the relationship of film thickness and deposition rate to position on a target for different combinations of periods of deposition and target to substrate distances.

In an example of the invention shown in Figure 4, a plane steel disc 11 2mm thick and 76mm diameter acts as the ferromagnetic target above a central magnetic material core 12 of mild steel and a ring of 12 cobalt samarium magnets 13 10mm diameter and 15mm long spaced around the magnetron in a pitch circle diameter of 63.5mm diameter. The mild steel core 11 is 19mm diameter and 15mm long and with an integral mild steel lower disc 14 forms the yoke of the magnetic assembly extending to the lower ends of the outer magnets 13.

The magnetic assembly is symmetrical around the axis of the magnetron, but it is unbalanced. Whereas the magnetic lines of force in Figure 1 are confined to the region over the target because the magnets are balanced, in the unbalanced arrangement of Figure 4 there are some magnetic lines of force above the ferromagnetic steel disc 11, but also there are lines of force from the peripheral magnetic poles around the outside of the magnets to the opposite poles on the base yoke because

CLAIMS

1. A magnetron comprising a ferromagnetic target and means to generate a magnetic field above the surface of the target including magnets in an unbalanced arrangement.

2. A magnetron as claimed in claim 1 wherein the magnets of the one polarity are arranged in a ring beneath the periphery of the target, and a magnet or magnets of the opposite polarity is or are arranged beneath the centre of the target.

3. A magnetron as claimed in claim 1 wherein the magnets of the one polarity are arranged in a ring beneath the periphery of the target, and magnetic material is arranged beneath the centre of the target.

4. A magnetron as claimed in claim 3 wherein the central magnetic material comprises mild steel.

5. A magnetron as claimed in claim 2 wherein the peripheral magnets are of permanently magnetised material.

6. A magnetron as claimed in claim 5 wherein the permanently magnetised material is a cobalt alloy.

7. A magnetron as claimed in any one of the preceding claims wherein wherein the target comprises a uniform plane disc.

8. A magnetron substantially as herein described with reference to the accompanying drawings.

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